Shorewall and Native IPSEC

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Linuxfest Northwest

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Disclaimers

- Although I am a Software Architect with Hewlett-Packard, Shorewall is completely my own work.
- Shorewall is not supported by HP in any way
- My main Linux expertise is in Networking and Firewalls but I don't claim to be an IPSEC expert

Background

- Virtual Private Networking (VPN) on Linux has followed a common model
- Prior to kernel 2.6, IPSEC followed that model, although IPSEC is not really a VPN mechanism.
- In kernel 2.6, a new model for IPSEC on Linux was introduced – I'll refer to that new model as *Native IPSEC*

Background (continued)

- Shorewall has had VPN support from the beginning (IPSEC support added in version 1.0.2).
- Shorewall VPN support was designed around the traditional Linux VPN model
- As a consequence, Native IPSEC is not well supported by Shorewall 2.0.* and earlier
- Support for Native IPSEC added in Shorewall 2.2.0.

Agenda

- IPSEC Overview
- IPSEC on Linux before Kernel 2.6
- IPSEC with Kernel 2.6 (Native IPSEC)
- Brief Shorewall Introduction
- Shorewall VPN Basics
- Shorewall support for Native IPSEC
- Example
- Conclusion – Q&A

IPSEC Overview

IPSEC — What is it?

- Mechanism for:
  - defining policies for secure communication in a network
  - enforcing those policies
  - defining how that communication is to be secured
  - defining how hosts authenticate themselves to each other

IPSEC Essential Reference

- http://www.ipsec-howto.org/
- Much of the information in this section of the presentation comes from there

IPSEC Basics

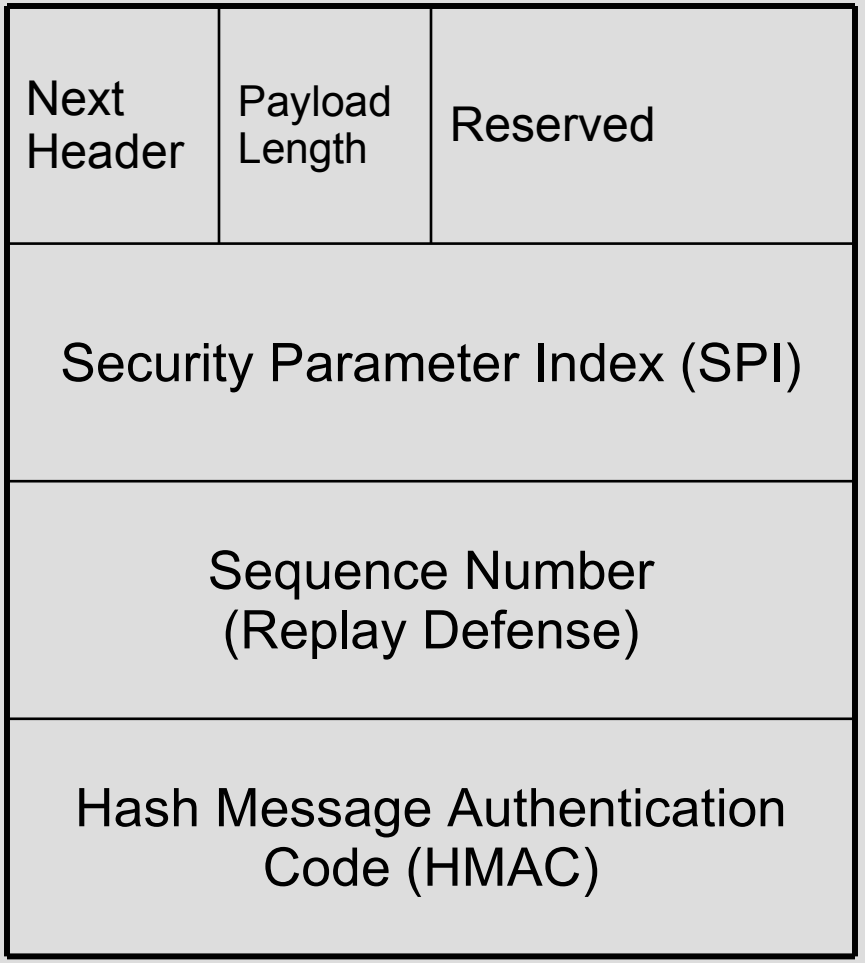
- Originally defined for IPV6
- “Back-ported” to IPV4
- Architecture is defined in RFC 2401
- Because it is a standard, it is widely implemented and supported
- Can be used to define complex encryption policies
- Is complex ☹

IPSEC Protocols

- Two different encapsulation protocols:
  - *Authentication Headers* (Protocol 51): Ensures datagram Integrity
  - *Encapsulated Security Payload* (Protocol 50): Ensures Datagram Integrity and optionally provides confidentiality via encryption.
- UDP port 500 (*Internet Security Association Key Management Protocol* -- ISAKMP)
- May also use IP Payload Compression Protocol (Protocol 108).

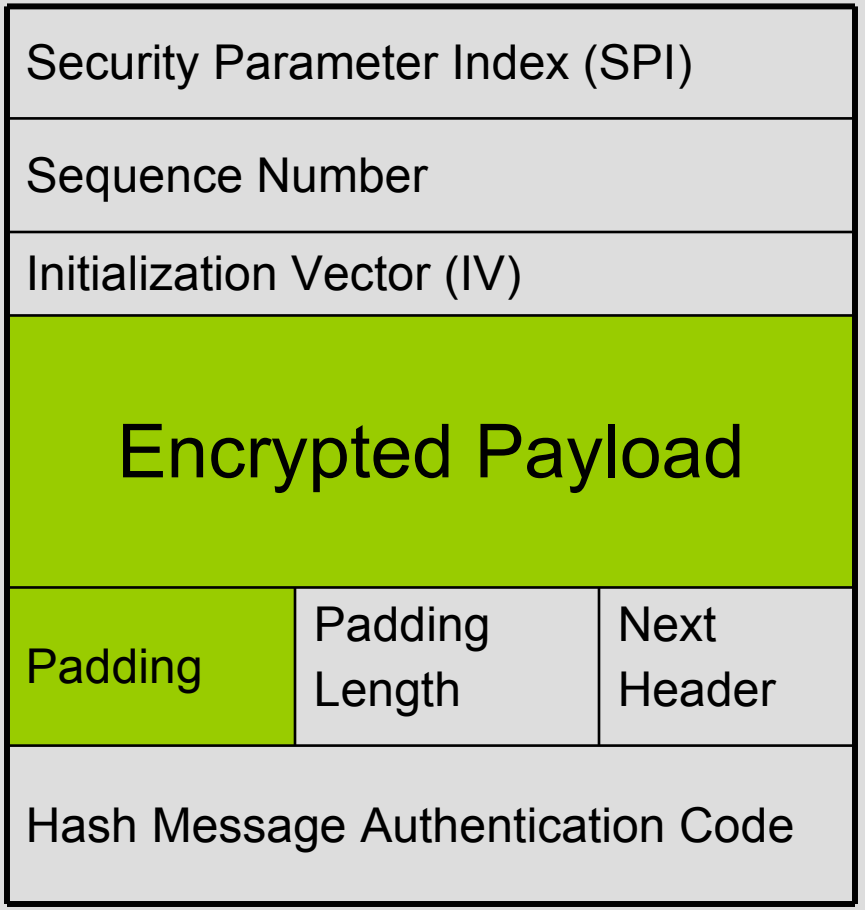
Authentication Headers (AH)

- HMAC is a cryptographic hash
- Includes IP addresses in the Header
- Hence AH cannot be used with NAT



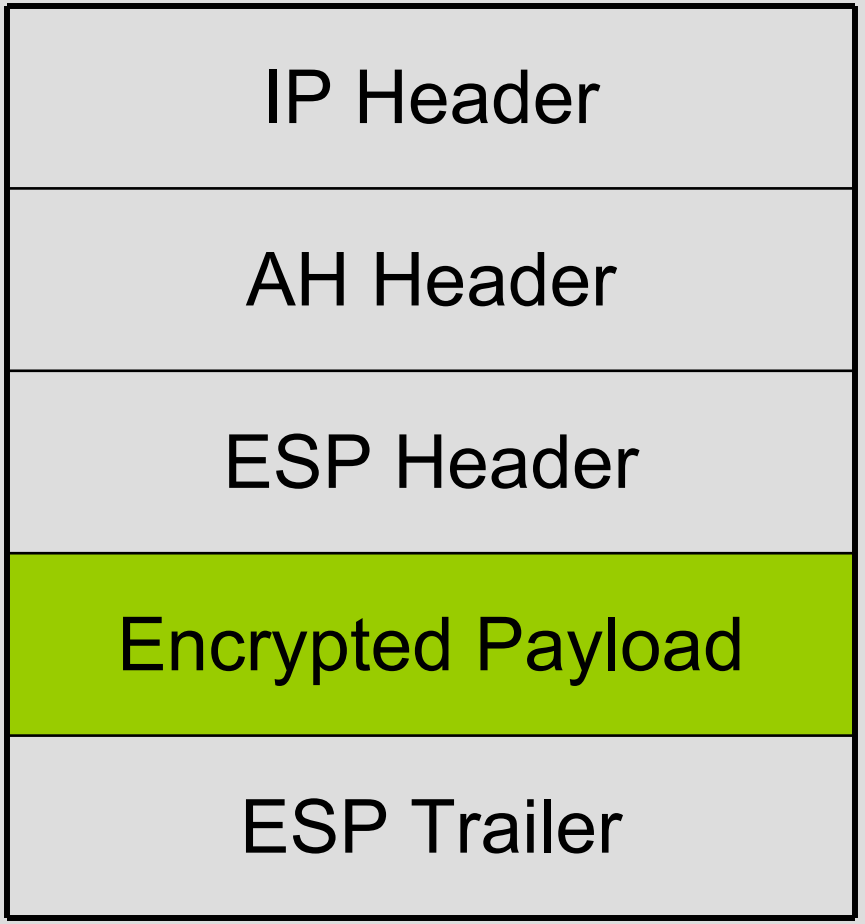
Encapsulated Security Payload (ESP)

- Uses a header and a trailer around the payload
- HMAC only includes data
- Still, NAT of ESP generally isn't possible



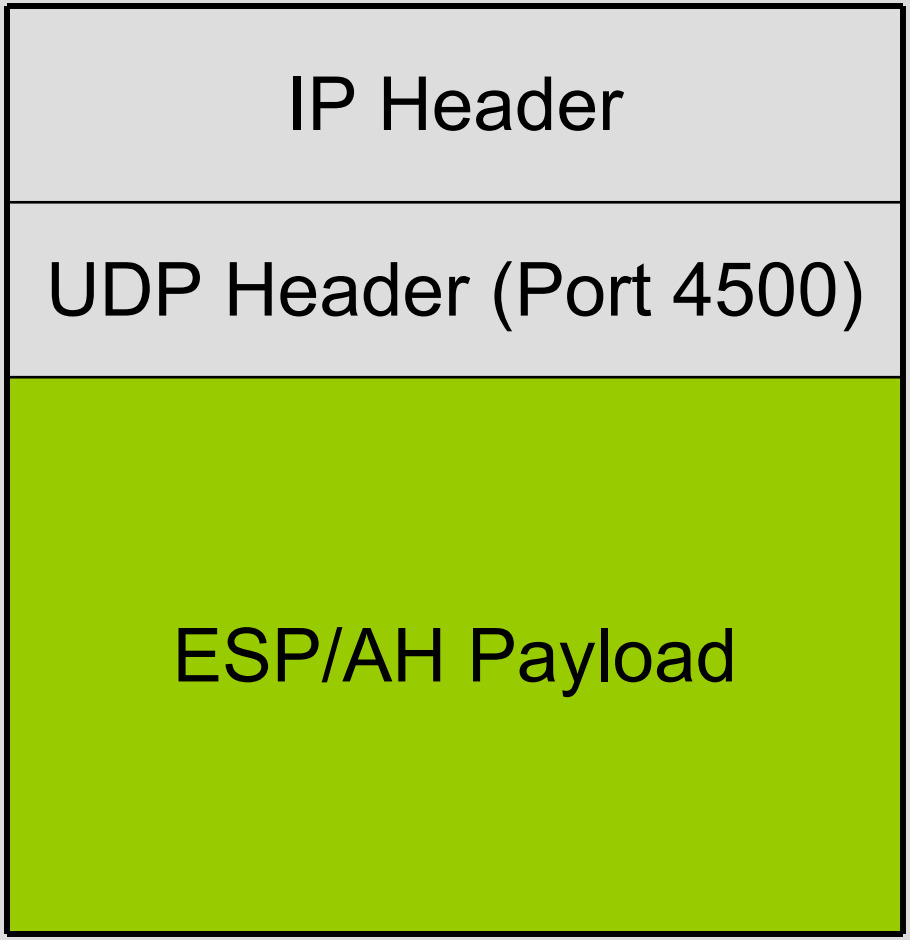
Using AH and ESP Together

- The integrity of the IP header of an encrypted packet can be ensured by encapsulating the ESP packet inside an AH packet.



Nat Traversal

- Routers using *Network Address Translation* (NAT) can rewrite the IP header without affecting the payload.

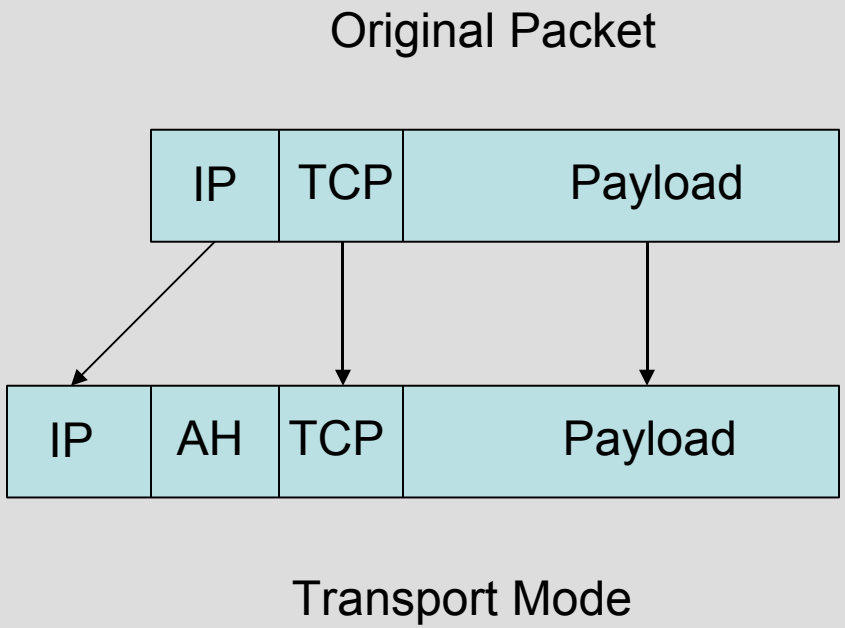


IPSEC Modes

- Two different modes
  - *Transport Mode* (host-to-host)
  - *Tunnel Mode* (gateway-to-gateway or gateway-to-host)

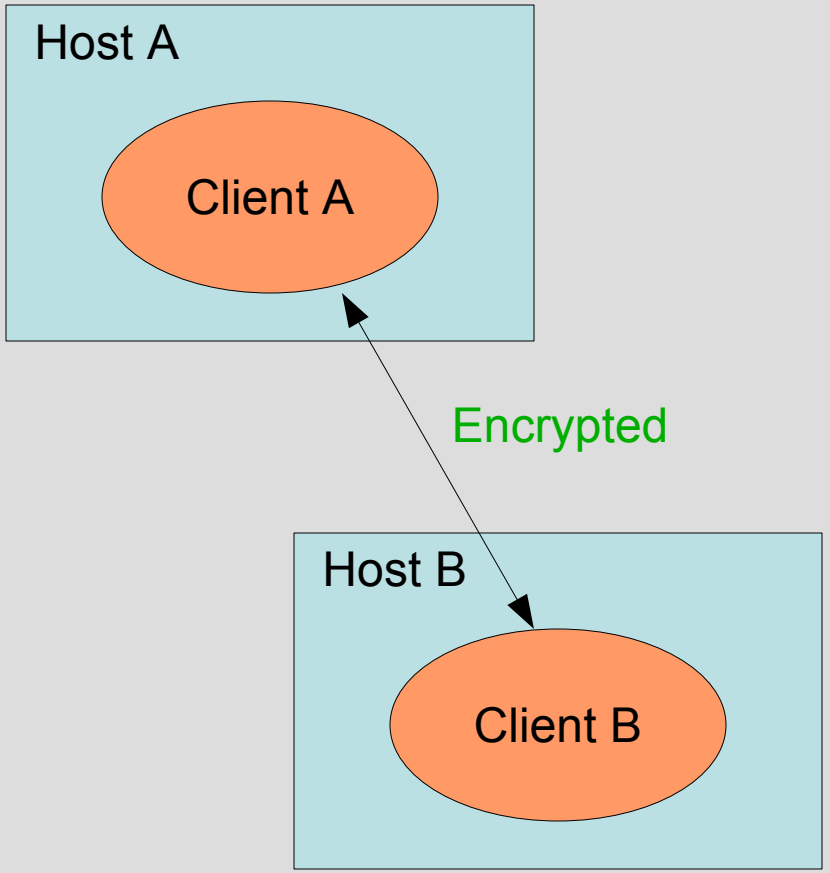
Transport Mode

- Encapsulates the payload
- The host to which the original IP packet is addressed is the host that will unencapsulate the transport mode packet



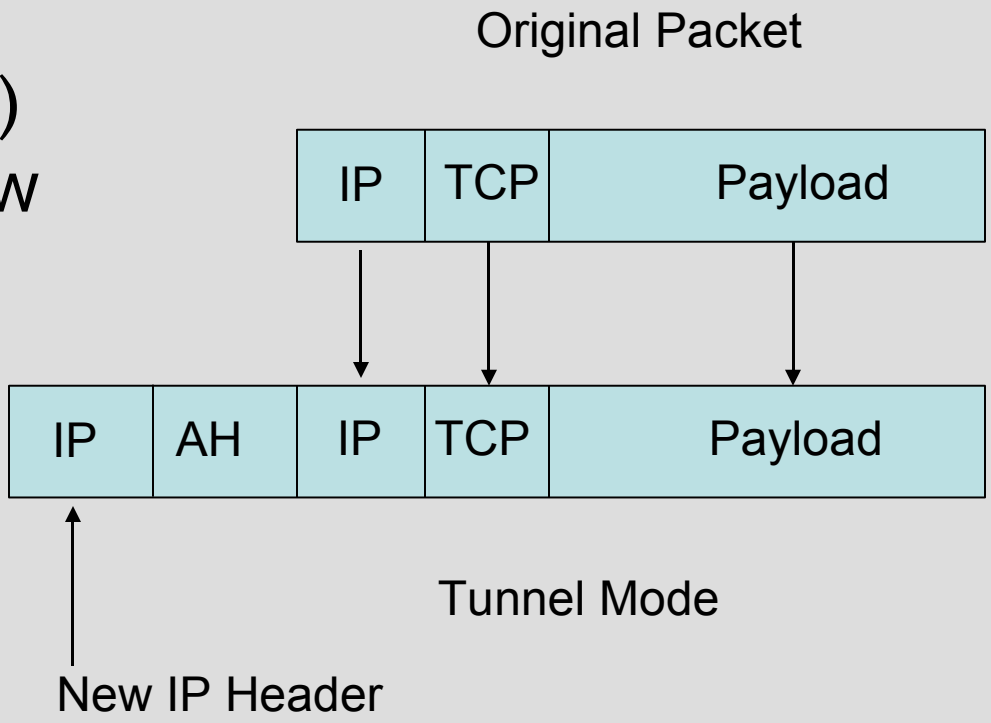
Transport Mode (continued)

- Host-to-host communication



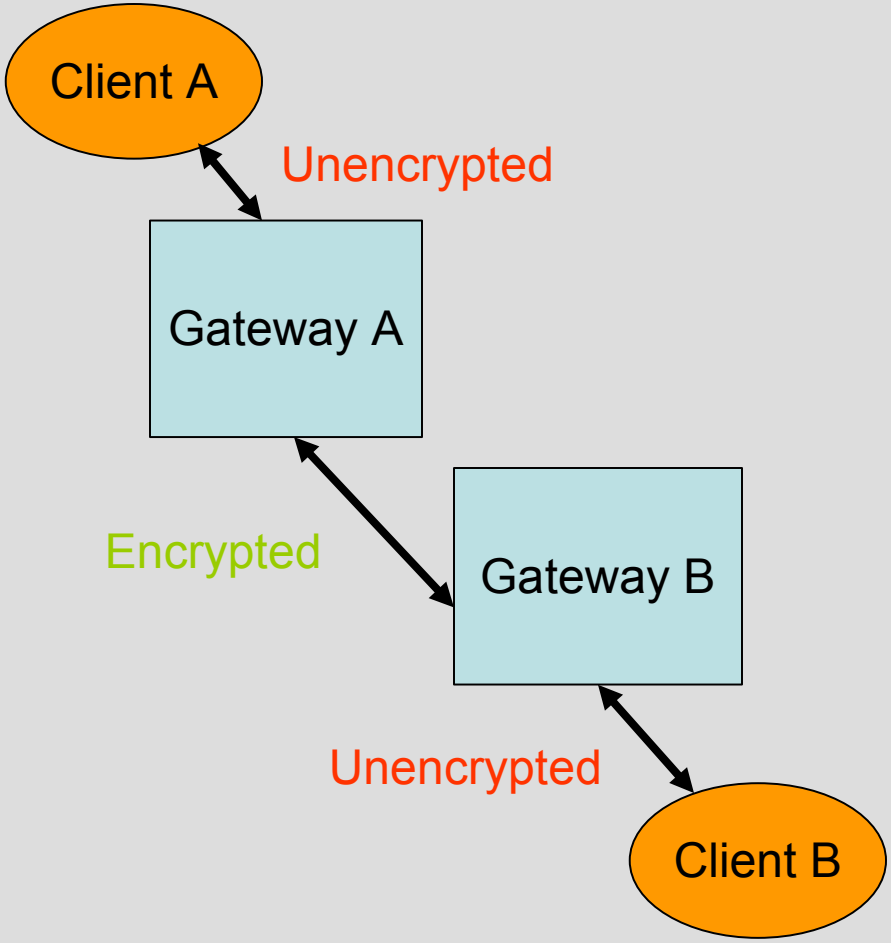
Tunnel Mode

- Encapsulates the entire IP packet
- The host (gateway) specified in the new IP header will decapsulate



Tunnel Mode (continued)

- Clients need not run on the gateways.
- Communication between client systems and gateways is not encrypted.



Security Associations

- A *Security Association* defines how secure traffic is to be encrypted by a sending host to send to a receiving host.
- The Security Association is uni-directional.
- Security Associations are stored in a *Security Association Database* (SAD).
- Security Associations are identified by their *Security Parameter Index* (SPI).

Security Associations (continued)

Example (from output of ‘setkey –D’):

```
192.168.3.8 192.168.3.254
        esp mode=tunnel spi=174516471(0x0a66e8f7) reqid=0(0x00000000)
        E: blowfish-cbc  2016fe36 13490de6 1b600abd 48be832d
        A: hmac-sha1  a3c475d3 c5b180cd ad5a242d be1bd559 554334e6
        seq=0x00000000 replay=4 flags=0x00000000 state=mature
        created: Apr  9 13:09:54 2005   current: Apr  9 13:29:12 2005
        diff: 1158(s)   hard: 14400(s)  soft: 11520(s)
        last: Apr  9 13:10:01 2005      hard: 0(s)      soft: 0(s)
        current: 81962(bytes)   hard: 0(bytes)  soft: 0(bytes)
        allocated: 817  hard: 0 soft: 0
        sadb_seq=3 pid=15610 refcnt=0
```

Security Associations (continued)

- Where multiple protocols are used (e.g., AH & ESP) multiple SAs are required to form an *SA Bundle*
- Security Associations may be statically defined but are usually negotiated using a *Keying Daemon* (racoon, isakmpd, pluto) using a method called the *Internet Key Exchange* (IKE)
- IKE uses the *Internet Security Association Key Management Protocol* (ISAKMP).
- ISAKMP uses UDP port 500 (source and destination)

Security Policies

- Define which traffic is *or is not* to be encrypted
- Define the mode (transport or tunnel)
- Define the Protocol (ESP/AH)
- Define the end-points
- Like Security Associations, Security Policies are uni-directional.
- Maintained by kernel in a *Security Policy Database* (SPD)

Security Policies (continued)

Example (from output of ‘setkey –DP’):

```
0.0.0.0/0[any] 192.168.3.8[any] any
        out ipsec
        esp/tunnel/192.168.3.254-192.168.3.8/require
        created: Apr 15 10:54:41 2005  lastused: Apr 23 13:12:36 2005
        lifetime: 0(s) validtime: 0(s)
        spid=1369 seq=7 pid=12140
        refcnt=11
```

IKE

- IKE defined in RFC2409
- Negotiation takes place in two Phases:
  1. Create an *ISAKMP Security Association* (ISAKMP SA), perform authentication. This phase may use either *aggressive mode* or *main mode*; main mode is preferred because it protects against “man in the middle” attacks.
  2. Create one or more IPSEC Security Associations (usually two, one in each direction) utilizing the *quick mode*.

IKE (continued)

- ISAKMP is a framework for key exchanges.
- One widely-supported key exchange algorithm is the *OAKLEY Key Determination Protocol*.
  - Defined in RFC 2412

IPSEC on Linux before Kernel 2.6

IPSEC before Kernel 2.6 (continued)

- FreeS/Wan and derivatives such as OpenS/Wan followed the traditional Linux model for VPN.
  - Create a special interface
  - Route VPN traffic through that interface

IPSEC before Kernel 2.6

- FreeS/Wan and derivatives
  - Created **`ipsec0, ipsec1,`** …
  - Routing used to direct traffic to be encrypted to one of these devices
  - Unencrypted traffic goes in/out of an **`ipsecN`** interface
  - Encrypted traffic goes from local<->remote gateway
  - Required patching kernel using FreeW/Wan patches

IPSEC with Kernel 2.6 (Native IPSEC)

Native IPSEC

- Uses the BSD Model
- Kernel maintains the *Security Policy Database* (SPD) that defines which traffic is to be encrypted, which mode (tunnel or transport), and the end-points.
- No **`ipsecN`** interfaces are created!
- No routing involved
- Kernel maintains SAD.
- No kernel patching required (theoretically)
- Very much a work-in-progress

2.6 Kernel Patches Required

- http://shorewall.net/pub/shorewall/contrib/IPSEC
  - Patches for kernel's 2.6.9 – 2.6.11
- http://www.netfilter.org
  - Patch-o-matic-ng "ipsec" patches (4) for kernels < 2.6.9
  - Patch-o-matic-ng "policy match" for all kernels and iptables
- Current SuSE™ 9.2 and 9.3 kernels and iptables are already patched!

ipsec-tools

- Product of the Kame project in Japan (BSD)
- http://ipsec-tools.sourceforge.net
  - setkey – Tool for configuring SPD and for querying SPD and SAD
  - racoon – Keying Daemon supporting ISAKMP/Oakley
- Currently at version 5.1 which I recommend
- >= 5.0 is required with Kernel 2.6.11
- In Debian, ipsec-tools and racoon are separate packages!

Configuring Security Policies -- setkey

- /etc/racoon/setkey.conf

```
# First of all flush the SAD and SPD databases

flush;
spdflush;

# Add some SPD rules

spdadd 0.0.0.0/0 192.168.3.8/32 any -P out ipsec
   esp/tunnel/192.168.3.254-192.168.3.8/require ;
spdadd 192.168.3.8/32 0.0.0.0/0 any -P in  ipsec
   esp/tunnel/192.168.3.8-192.168.3.254/require ;
```

Configuring Racoon

- /etc/racoon/racoon.conf

```
path certificate "/etc/certs" ;

listen
{
        isakmp 206.124.146.176 ;
        isakmp 192.168.3.254 ;
        isakmp_natt 206.124.146.176 [4500] ;
        adminsock "/usr/local/var/racoon/racoon.sock"
              "root" "operator" 0660 ;
}
```

Configuring Racoon – Phase 1

- /etc/racoon/racoon.conf

```
#
# Tipper at Home --
#
remote 192.168.3.8
{
        exchange_mode main ;
        certificate_type x509 "gateway.pem" "gateway_key.pem" ;
        verify_cert on ;
        my_identifier asn1dn ;
        peers_identifier asn1dn "C=US, ST=Washington, L=Shoreline, O=Shoreline Firewall,
                  CN=tipper.shorewall.net/emailAddress=postmaster@shorewall.net" ;
        verify_identifier on ;
        lifetime time 4 hour ;
        proposal {
                encryption_algorithm blowfish ;
                hash_algorithm sha1 ;
                authentication_method rsasig ;
                dh_group 2 ;
        }
}
```

Configuring Racoon – Phase 2

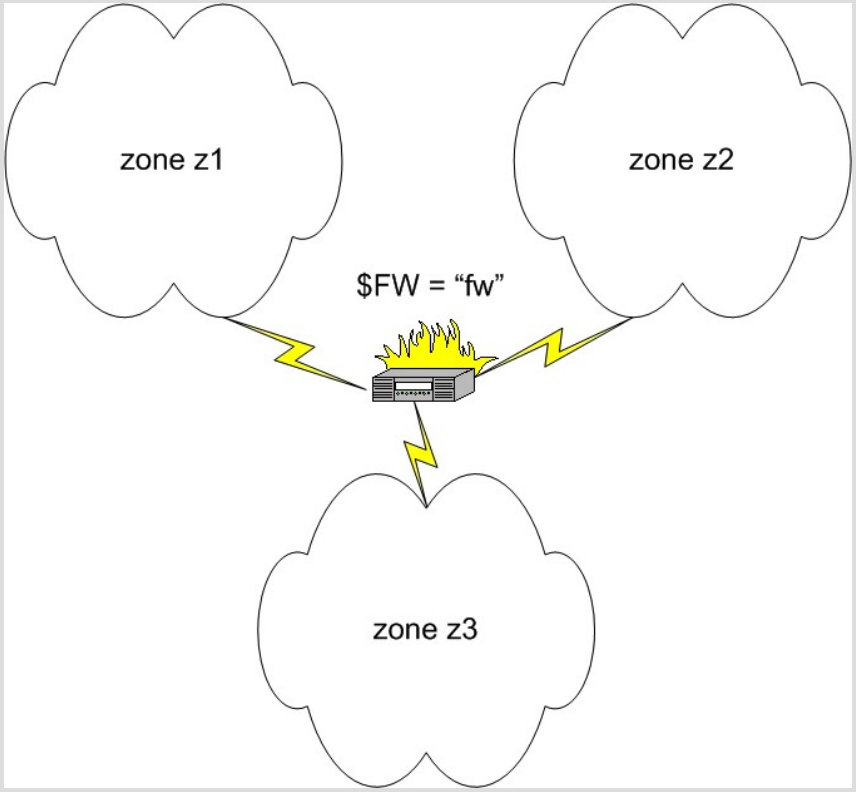
- /etc/racoon/racoon.conf

```
sainfo address 0.0.0.0/0 any address 192.168.3.8 any
{
        pfs_group 2 ;
        lifetime time 4 hour ;
        encryption_algorithm blowfish ;
        authentication_algorithm hmac_sha1, hmac_md5 ;
        compression_algorithm deflate ;
}
```

Brief Shorewall Introduction

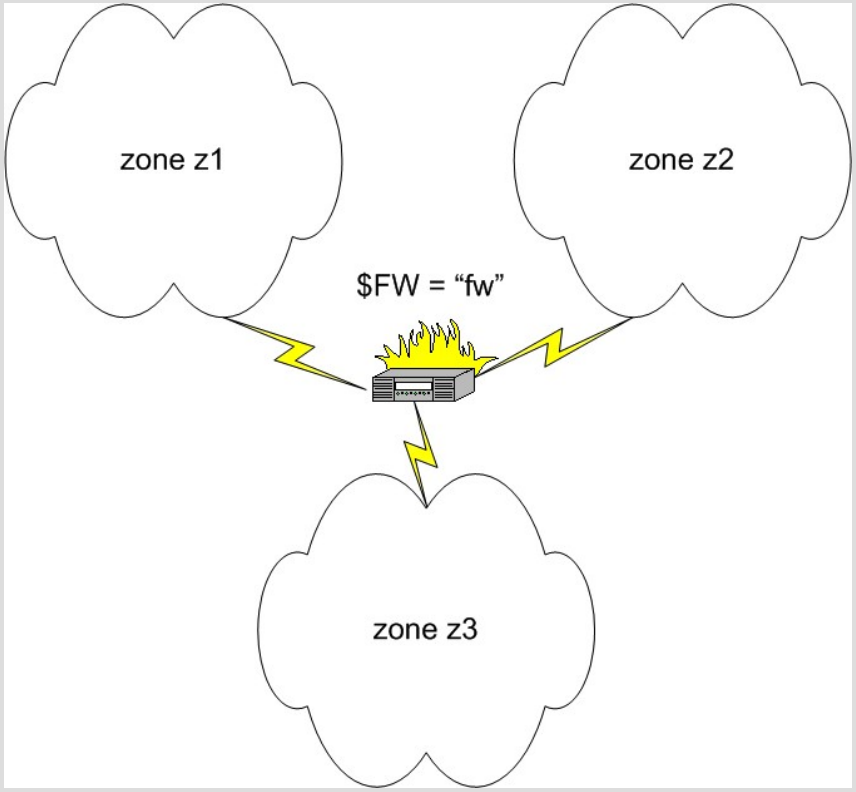
Shorewall Basics - Zone Based

- Shorewall sees the network that it is a part of as consisting of a set of *zones*
- The firewall itself comprises the zone called ‘fw’ (default value of variable $FW).
- Zones other than $FW are defined in /etc/shorewall/zones



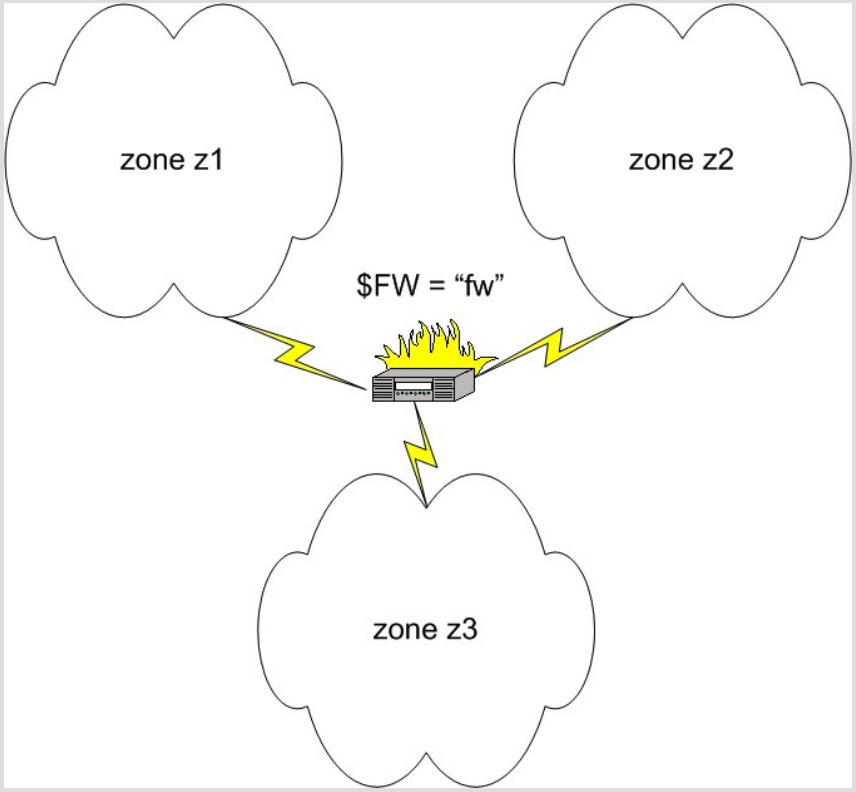
Zone Based (continued 2 of 4)

- Simplest model is one zone per firewall network interface. Defined in /etc/shorewall/interfaces.
- Zones are normally disjoint but may be overlapping or nested. These are defined in /etc/shorewall/hosts.



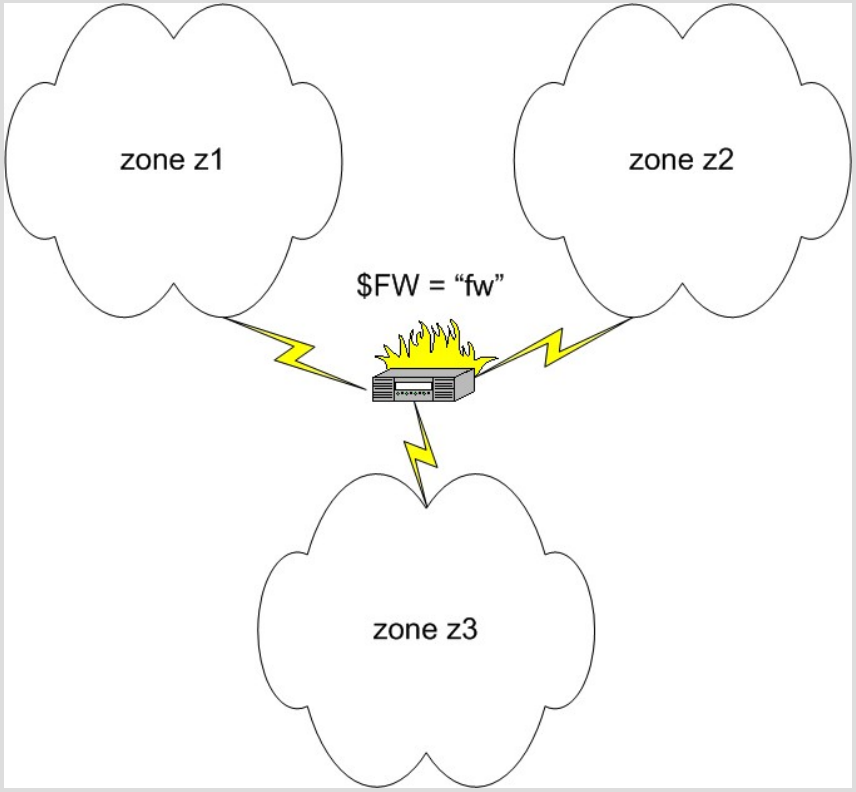
Zone Based (continued - 3 of 4)

- Shorewall assigns no meaning to zone names (1-5 characters)
- Shorewall allows you to specify a *policy* for connections between each pair of zones:
  - ACCEPT (allow)
  - REJECT (disallow)
  - DROP (ignore – stealth)
- Policies are defined in /etc/shorewall/policy



Zone Based (continued – 4 of 4)

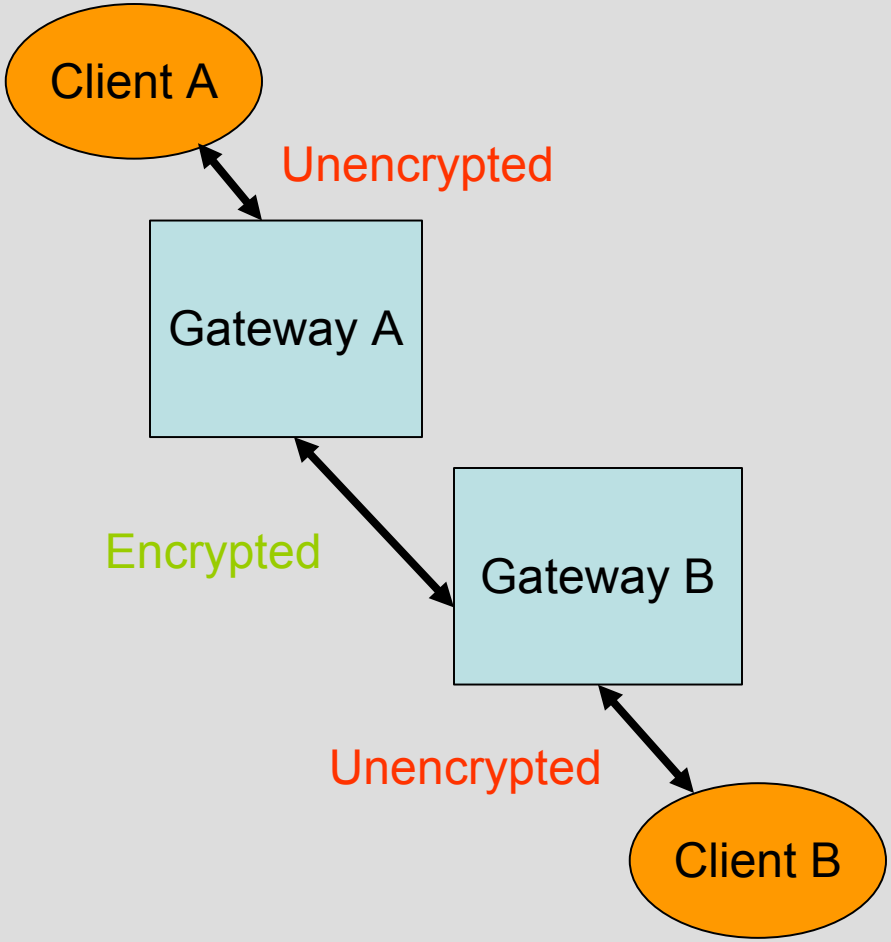
- *Rules* are exceptions to policy and are defined in /etc/shorewall/rules.
- Example:
  - *Policy: Z1 Z2 REJECT*
  - *Rule: ACCEPT Z1 Z2 tcp telnet*



Shorewall VPN Basics

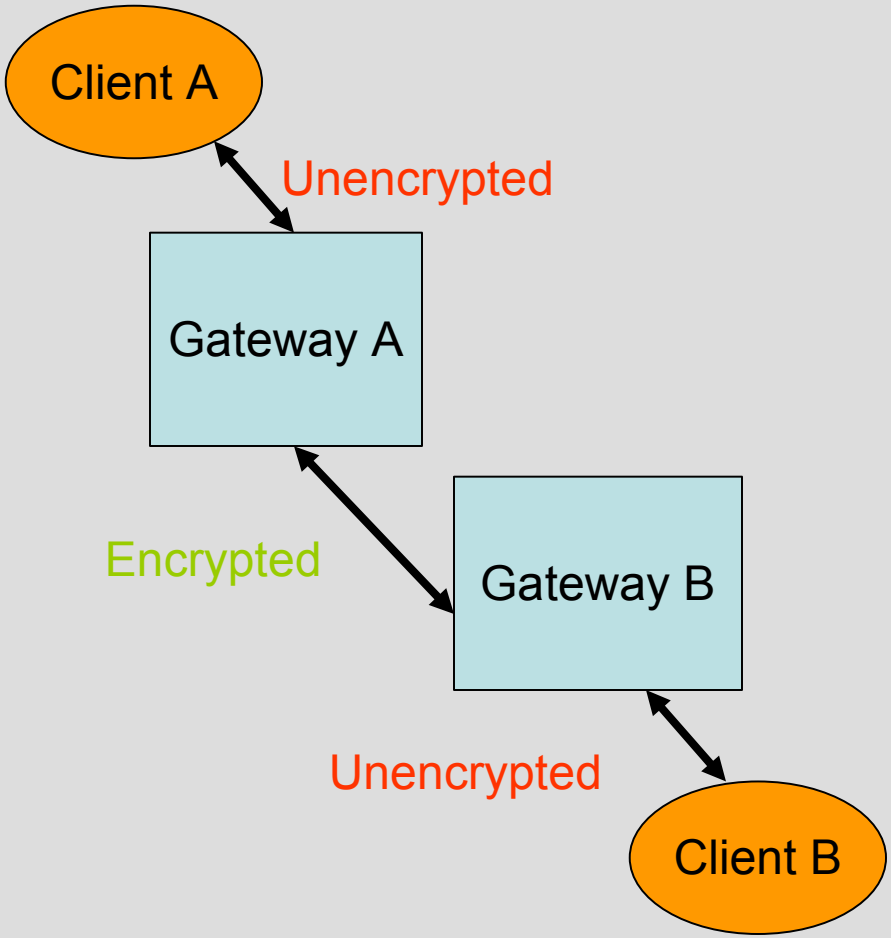
Shorewall VPN Basics

- Shorewall typically runs on VPN end-points/gateways
- Clients communicate unencrypted with the gateway.
- Gateway encrypts the traffic and sends encrypted version it to the other gateway.
- Other gateway decrypts and sends decrypted copy to receiving client.



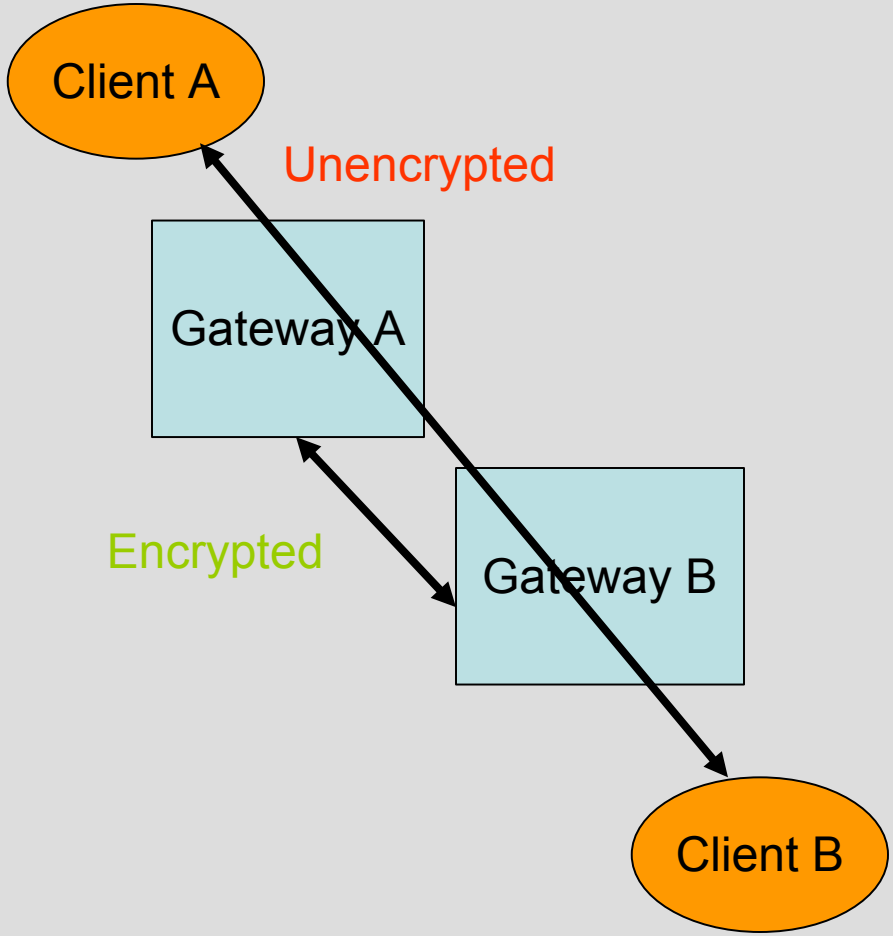
Shorewall VPN Basics (Continued)

- Clients may run on the gateways themselves or on other computers behind the gateways.



Shorewall VPN Basics (Continued)

- Gateways must deal with two types of traffic:
  1. Unencrypted traffic between the clients.
  2. Encrypted traffic between the gateways.
- Each packet passes through Netfilter twice in each gateway!
  1. Once unencrypted
  2. Once encrypted



Shorewall VPN Basics (Continued)

- Encrypted traffic is defined using the /etc/shorewall/tunnels file.
  - Note that transport-mode encrypted traffic can still be handled in the tunnels file.
- Unencrypted traffic is handled normally (through policies and rules).

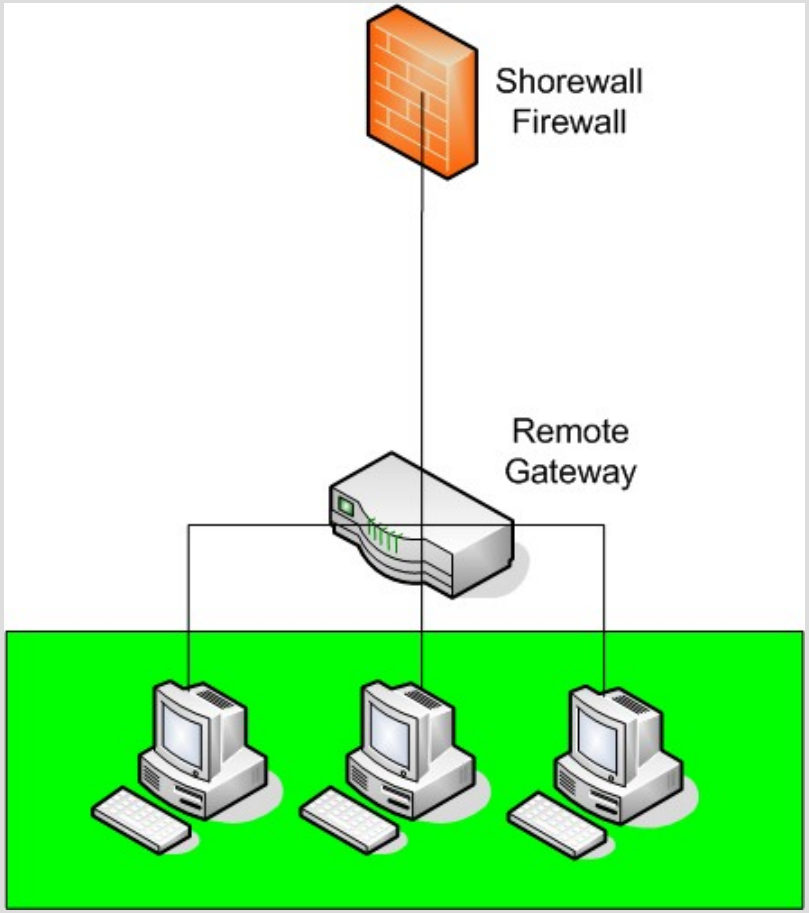
Shorewall VPN Basics (Continued)

- Columns in the tunnels file are:
  1. TYPE –
     - **ipsec** (AH and ESP – no NAT traversal)
     - **ipsecnat** (AH, ESP and optional NAT traversal)
     - Either may be followed by **:noah** (e.g., ipsec:noah) to omit rules for AH.
  2. ZONE – the zone that the other gateway is in.
  3. GATEWAY – the IP address of the other gateway (may be specified as a network or 0.0.0.0/0)

- Use of /etc/shorewall/tunnels is optional; see:
  http://shorewall.net/VPNBasics.html

Shorewall VPN Basics (continued)

- Usually define a zone for “the host(s) at the other end of the tunnel”.
- May or may not include the remote gateway



Pre-2.6 IPSEC Fit Shorewall's Tunnel Model

- Define "host(s) at the other end of the tunnel" zone using **`ipsecN`** interface

/etc/shorewall/interfaces:

```
#ZONE      INTERFACE                OPTIONS
vpn        ipsec0                   ...
```

/etc/shorewall/hosts:

```
#ZONE      HOSTS                    OPTIONS
vpn        ipsec0:192.168.1.0/24    ...
```

2.6 IPSEC Does Not Fit Shorewall's Tunnel Model

- Could define "host(s) at the other end of the tunnel" zone using **`real`** interface to remote gateway. This sort of works with Shorewall 2.0.*.

  /etc/shorewall/hosts:

```
#ZONE      HOSTS                    OPTIONS
vpn        eth0:192.168.1.0/24      …
```

- But we can't guarantee that traffic to those hosts will actually be encrypted.

Shorewall Support for Native IPSEC

Defining an IPSEC zone with Shorewall 2.2.*

1. Use /etc/shorewall/hosts only:

```
#ZONE      HOSTS                    OPTIONS
vpn        eth0:192.168.1.0/24      ipsec,…
```

   - For unencrypted traffic outbound on eth0 to 192.168.1.0/24:
     - Traffic that *will be encrypted using IPSEC* is going to zone **vpn**.
   - For unencrypted traffic from 192.168.1.0/24 received on eth0:
     - Traffic that *was unencrypted using IPSEC* is coming from zone **vpn.**

Defining an IPSEC zone with Shorewall 2.2.* (continued)

2. Use /etc/shorewall/ipsec and /etc/shorewall/interfaces

/etc/shorewall/ipsec:

```
#ZONE  IPSEC  OPTIONS        IN              OUT
#                            OPTIONS         OPTIONS
vpn    Yes
```

/etc/shorewall/interfaces

```
#ZONE  INTERFACE     BROADCAST           OPTIONS
vpn    eth0          192.168.1.255       …
```

Defining an IPSEC zone with Shorewall 2.2.* (continued)

2. Use /etc/shorewall/ipsec and /etc/shorewall/interfaces (continued)
   - For unencrypted traffic outbound on eth0:
     - Traffic that *will be encrypted using IPSEC* is going to zone **vpn**.
   - For unencrypted traffic from received on eth0:
     - Traffic that *was unencrypted using IPSEC* is coming from zone **vpn.**
   - The vpn zone is said to be *an IPSEC zone*.

Defining an IPSEC zone with Shorewall 2.2.* (continued)

3. Use /etc/shorewall/ipsec with /etc/shorewall/hosts.

We will see an example later in the presentation.

Problem – TCP MSS

- MTU Path discovery (RFC 1191) depends on delivery of “fragmentation needed” ICMP packets and uses the MSS option in TCP SYN and SYN,ACK packets.
- Naïve network administrators believe that ICMP == evil and block it.
- Result: Communication problems
  - Small messages are OK
  - Large messages are dropped

TCP MSS (continued)

- Most commonly is a problem when the some sort of encapsulation occurs. PPPoE is an example.
- Also occurs in IPSEC
- Usual workaround is to use the Shorewall CLAMPMSS option in shorewall.conf.
- CLAMPMSS=yes causes the MSS option to be set to the minimum of its value and MTU minus 40.

TCP MSS (continued)

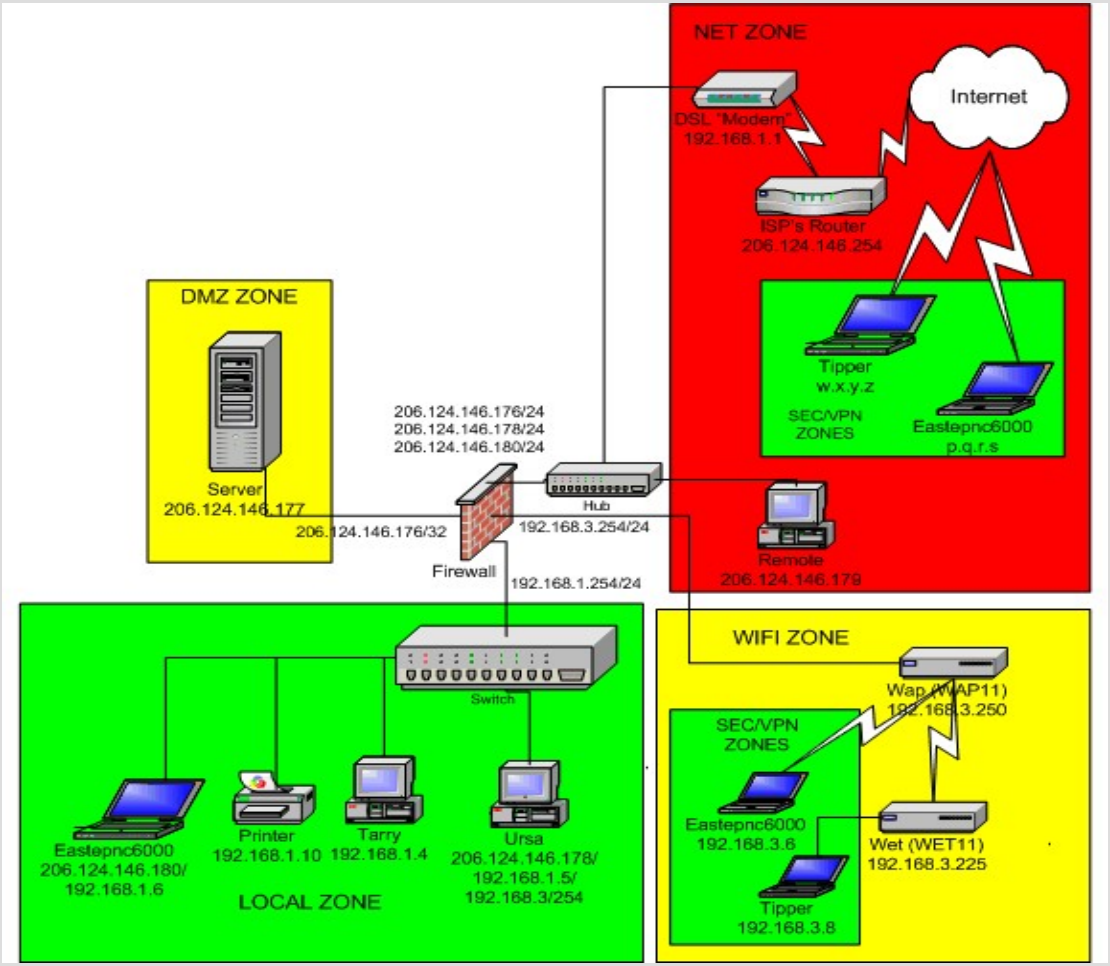
- CLAMPMSS=<number> causes the MSS option to be set to the minimum of its current value and <number>

TCP MSS (continued)

- But in the case of Kernel 2.6 IPSEC, the device MTU doesn't reflect the length of the IPSEC headers.
- Hence CLAMPMSS=Yes isn't effective and CLAMPMSS=<number> affects ALL TCP connections.
- Solution: Use the 'mss=' option in /etc/shorewall/ipsec.

Example

My Network


NET ZONE
Internet
DSL "Modem"
192.168.1.1
ISP's Router
206.124.146.254
Tipper
w.x.y.z
SEC/VPN
ZONES
Eastepnc6000
p.q.r.s
DMZ ZONE
Server
206.124.146.177
206.124.146.176/24
206.124.146.178/24
206.124.146.180/24
206.124.146.176/32
Firewall
Hub
192.168.3.254/24
Remote
206.124.146.179
192.168.1.254/24
Switch
WIFI ZONE
Wap (WAP11)
192.168.3.250
SEC/VPN
ZONES
Eastepnc6000
192.168.3.6
Wet (WET11)
192.168.3.225
Tipper
192.168.3.8
Eastepnc6000
206.124.146.180/
192.168.1.6
Printer
192.168.1.10
Tarry
192.168.1.4
Ursa
206.124.146.178/
192.168.1.5/
192.168.3/254
LOCAL ZONE

Security Policies

- /etc/racoon/setkey.conf

```
# First of all flush the SAD and SPD databases

flush;
spdflush;

# Add some SPD rules for Tipper

spdadd 0.0.0.0/0 192.168.3.8/32 any -P out ipsec
   esp/tunnel/192.168.3.254-192.168.3.8/require ;
spdadd 192.168.3.8/32 0.0.0.0/0 any -P in  ipsec
   esp/tunnel/192.168.3.8-192.168.3.254/require ;
```

- I don't specify a policy for the XP box (couldn't get it to work)

Racoon

- /etc/racoon/racoon.conf

```
path certificate "/etc/certs" ;

listen
{
        isakmp 206.124.146.176 ;
        isakmp 192.168.3.254 ;
        isakmp_natt 206.124.146.176 [4500] ;
        adminsock "/usr/local/var/racoon/racoon.sock" "root"
                        "operator" 0660 ;
}
```

Racoon – Phase 1
Tipper Wireless

- /etc/racoon/racoon.conf

```
#
# Tipper at Home --
#
remote 192.168.3.8
{
        exchange_mode main ;
        certificate_type x509 "gateway.pem" "gateway_key.pem" ;
        verify_cert on ;
        my_identifier asn1dn ;
        peers_identifier asn1dn "C=US, ST=Washington, L=Shoreline, O=Shoreline Firewall,
                  CN=tipper.shorewall.net/emailAddress=postmaster@shorewall.net" ;
        verify_identifier on ;
        lifetime time 4 hour ;
        proposal {
                encryption_algorithm blowfish ;
                hash_algorithm sha1 ;
                authentication_method rsasig ;
                dh_group 2 ;
        }
}
```

Racoon – Phase 2
Tipper Wireless

- /etc/racoon/racoon.conf

```
sainfo address 0.0.0.0/0 any address 192.168.3.8 any
{
        pfs_group 2 ;
        lifetime time 4 hour ;
        encryption_algorithm blowfish ;
        authentication_algorithm hmac_sha1, hmac_md5 ;
        compression_algorithm deflate ;
}
```

Racoon – Phase 1 Work Laptop Wireless Windows™ XP

- /etc/racoon/racoon.conf

```
#
# Work Laptop at Home -- 3des is the best alternative that XP supports.
#
remote 192.168.3.6 inherit 192.168.3.8
{
        passive on ;
        proposal_check obey ;
        peers_identifier asn1dn "C=US, ST=Washington, L=Shoreline,
                  O=Shoreline Firewall,
      CN=eastepnc6000.americas.cpqcorp.net/emailAddress=tom.eastep@hp.com"
                  ;
        generate_policy on ;
        lifetime time 4 hour ;
        proposal {
                encryption_algorithm 3des ;
                hash_algorithm sha1 ;
                authentication_method rsasig ;
                dh_group 2 ;
        }
}
```

Racoon – Phase 2 Work Laptop Wireless Windows™ XP

- /etc/racoon/racoon.conf

```
sainfo address 0.0.0.0/0 any address 192.168.3.6 any
{
        pfs_group 2 ;
        lifetime time 4 hour ;
        encryption_algorithm 3des ;
        authentication_algorithm hmac_sha1, hmac_md5 ;
        compression_algorithm deflate ;
}
```

Racoon – Phase 1 Roadwarriors

- /etc/racoon/racoon.conf

```
#
# Both systems on the road -- We use 3des for phase I to
#                             accomodate XP. Since we don't know
#                             the IP address of the remote host
#                             ahead of time, we must use
#                             "anonymous".
#
remote anonymous inherit 192.168.3.6
{
        nat_traversal on ;
        ike_frag on;
}
```

Racoon – Phase 2 Roadwarriors

- /etc/racoon/racoon.conf

```
sainfo anonymous
{
        pfs_group 2;
        lifetime time 4 hour ;
        encryption_algorithm blowfish, 3des;
        authentication_algorithm hmac_sha1, hmac_md5 ;
        compression_algorithm deflate ;
}
```

Shorewall /etc/shorewall/zones

```
#ZONE           DISPLAY         COMMENTS
sec             Secure          IPSEC Secure Zone
```

Shorewall /etc/shorewall/ipsec

```
#ZONE    IPSEC    OPTIONS          IN                OUT
#        ONLY                      OPTIONS           OPTIONS
sec      Yes      mode=tunnel      mss=1400
```

Shorewall /etc/shorewall/interfaces

```
#ZONE     INTERFACE       BROADCAST       OPTIONS
#
net       $EXT_IF         -               …
Wifi      $WIFI_IF        -               dhcp,maclist
```

- Note that I use MAC verification on my wireless network.

Shorewall /etc/shorewall/hosts

```
#ZONE          HOST(S)                          OPTIONS
sec            $WIFI_IF:192.168.3.0/24
sec            $EXT_IF:0.0.0.0/0
```

- Note that since the *sec* zone is defined as an IPSEC zone in /etc/shorewall/ipsec, I don't have to specify *ipsec* in the OPTIONS column.

Conclusion – Q&A

Where to Find More Information

- http://www.ipsec-howto.org/
- http://ipsec-tools.sourceforge.net/
- http://shorewall.net
  - http://shorewall.net/IPSEC-2.6.html
  - http://shorewall.net/IPSEC.htm
  - http://shorewall.net/myfiles.htm
  - http://shorewall.net/VPNBasics.html

Q & A